# AD 269 793

AID Report 61-155

28 November 1961

# SOVIET LITERATURE ON PROTECTIVE STRUCTURES AND COMPONENTS

AID Work Assignment No. 13

Report 3



Science and Technology Branch

Aerospace Information Division

AID Report 61-155 28 November 1961

# SOVIET LITERATURE ON PROTECTIVE STRUCTURES AND COMPONENTS

AID Work Assignment No. 13

Report 3



Science and Technology Branch

Aerospace Information Division

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

This is the third of a series of reports reviewing Soviet developments in the construction of protective structures and components of automatic weapons systems. This report is based on materials received at the Aerospace Information Division prior to 15 Oct 1961. It deals with the following topics:

A-1. Railroad systems
A-2. Road transportation
B. Construction activities associated with missle sites
B-1. Excavating and grading activity
B-4. Construction equipment
C-7. Guidance operations facilities
D-2. Propellant-handling equipment
E-4. Liquid-oxygen plants

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

TOPIC A-1. RAILROAD SYSTEMS

1.) Giant railroad cars. Ekonomicheskaya gazeta, 19 Jul 1961, 1.

The first lot of gondola-type railroad cars with 125-ton capacities has been assembled at the Uralvagonzavod [Ural Railroad-Car Plant]. Each car has a useful volume of 138 $m^3$ -- more than twice that of cars in use at present. Ural railroad-car builders have designed another large gondola car with a 100-ton capacity. The body of this car is constructed of an aluminum alloy which decreases car weight by one and one-half tons.

2.) 1. Ostrov, A. B. New State Standards for railroad clearances. Zheleznodorozhnyy transport, no. 3, Mar 1960, 10-15.

2. Bakayeva, V. G., ed. Transport SSSR [USSR Transportation]. Moskva, Morskoy transport, 1960. 537 p.

3. Ostrov, A. B. Unification of railroad clearances of Socialist countries Zheleznodorozhnyy transport, no. 2, Feb 1959, 87-93.

As of 1 Jan 1960, the new ГОСТ 9238-59 standard of clearances for railroads with 1524-mm-wide track became effective, replacing the ОСТ ВКС 6435 standard, introduced in 1934 [1]. The new standard is to be used in the building of new railroads and second tracks for existing single-track lines; the reconstruction and electrification of existing railroads; and the building and modernization of rolling stock. For all new railroads, railroads undergoing reconstruction, and those scheduled for reconstruction, the new ГОСТ establishes a common "track clearance" "С" (Fig. 1). This is a contour showing the closest distances by which any railroad construction or building (including bridges and tunnels) must clear straight track. On curved portions of track, clearances must be increased to maintain the same safety of passage as for a two-axis car 24 m long on straight track under maximum-speed conditions.

The new ГОСТ also specifies maximum outside perimeters of rolling stock. These perimeters are divided into two groups. One group includes perimeters Т (Fig. 2) and 1-Т (Fig. 3) for rolling stock operating exclusively on Soviet railroads. Perimeters Т and 1-Т accomodate all types of rolling stock operating within the USSR, but 1-Т does not include rolling stock of suburban electrified sections.

The second group includes perimeters 0-Т, 01-Т, 02-Т, and 03-Т for rolling stock operating both within the USSR and, with some limitations,

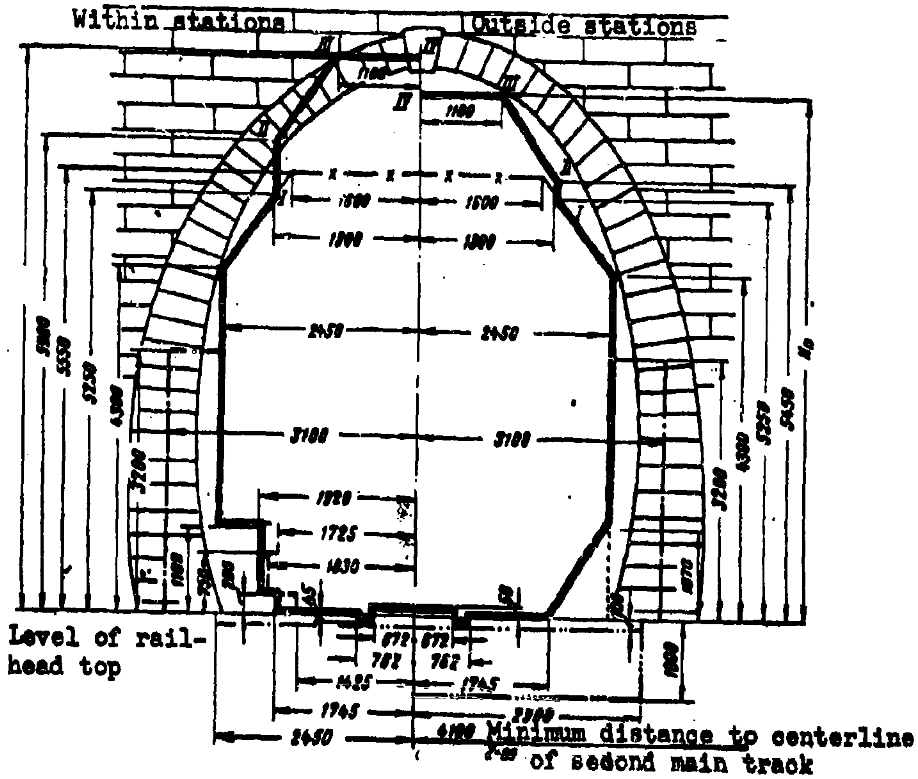
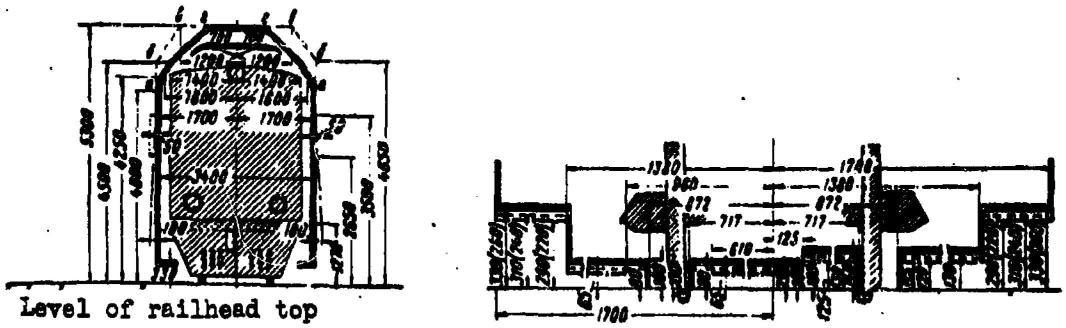


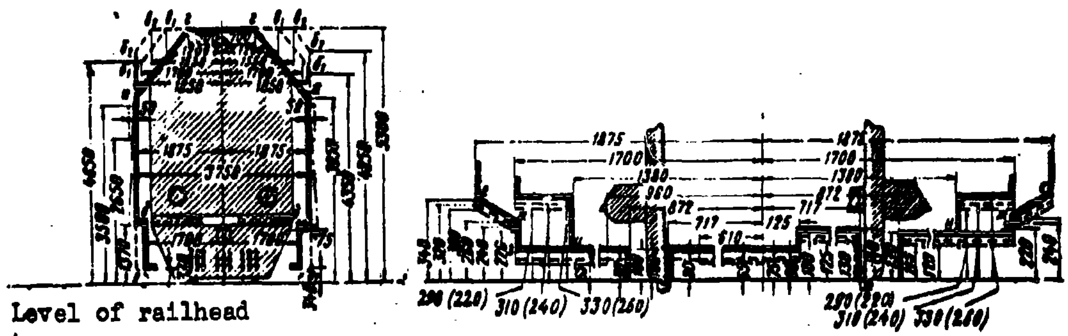

Fig. 1. Contour C

| | |
|---|---|
| ——x—— | Secondary or temporary-type railroad constructions with no prospects of electrification. |
| ------- | Temporary exception for railroads which do not use rolling stock of the T perimeter. |
| —·—·—·— | Minimum distance for all new buildings and constructions. In special cases, the Ministry of Railroads may permit reduction of this distance to 2450 mm inside and 2750 mm outside stations. |
| —··—··— | Maximum height for any device inside or outside stations except switching and signaling equipment, flooring on highway crossings, and the like. |
| —···—···— | Minimum distance for all new foundations and underground installations. |
| ······· | Tunnels and bridge railings. |



Level of railhead top

Fig. 2. Perimeter 1-T

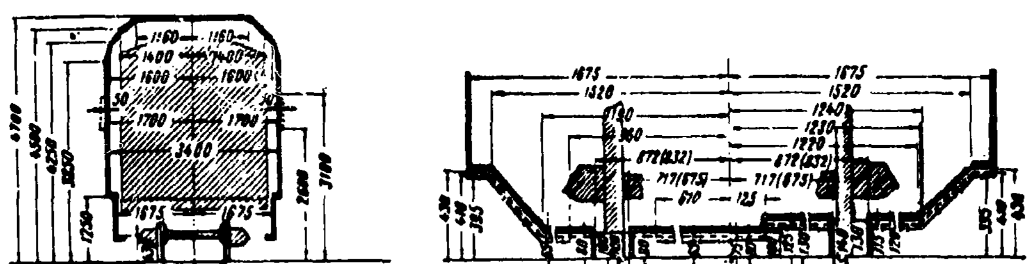


Level of railhead top

Fig. 3. Perimeter T

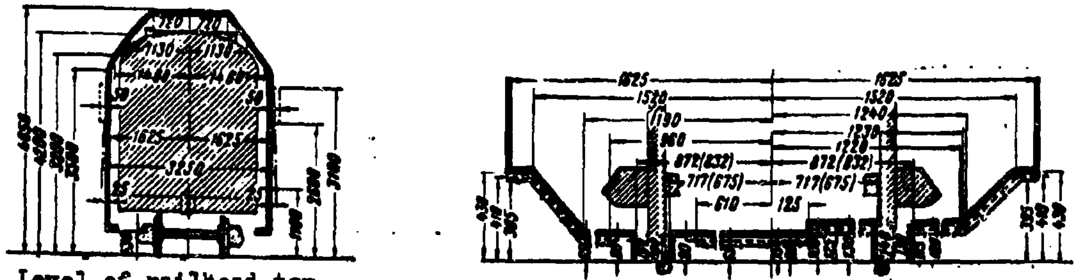
....... Signaling devices only.

—·—·—·— In 1-T and T perimeters for protruding noncritical parts. In 01-T perimeter only, for rolling stock built prior to introduction of this standard.



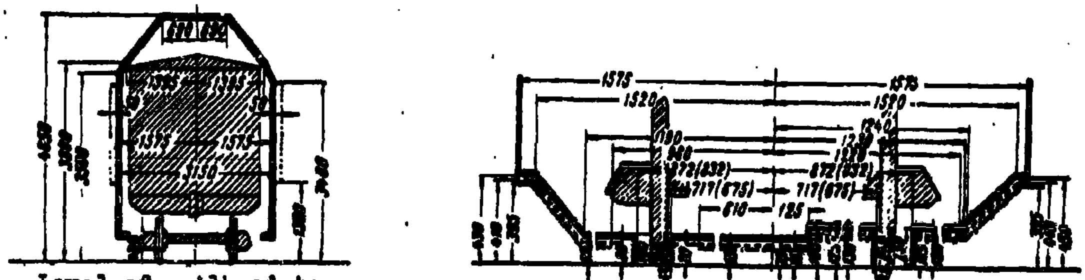
Level of railhead top

Fig. 4. Perimeter OT



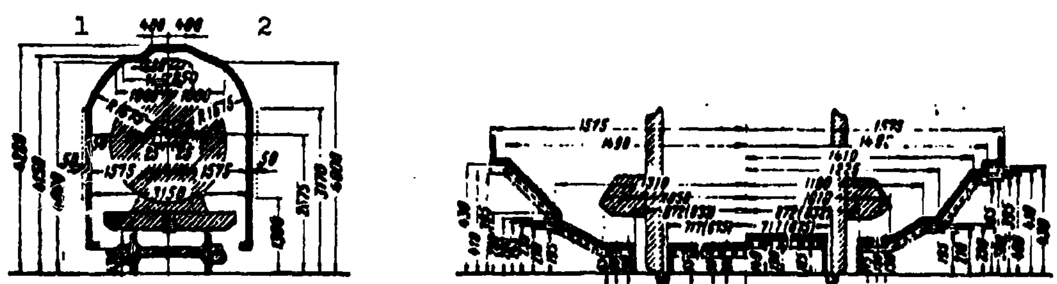
Level of railhead top

Fig. 5. Perimeter 01-T



Level of railhead top

Fig. 6. Perimeter 02-T




Level of railhead top

Fig. 7. Perimeter 03-T

1 - for locomotives, tenders, and motorized cars; 2 - for cars.

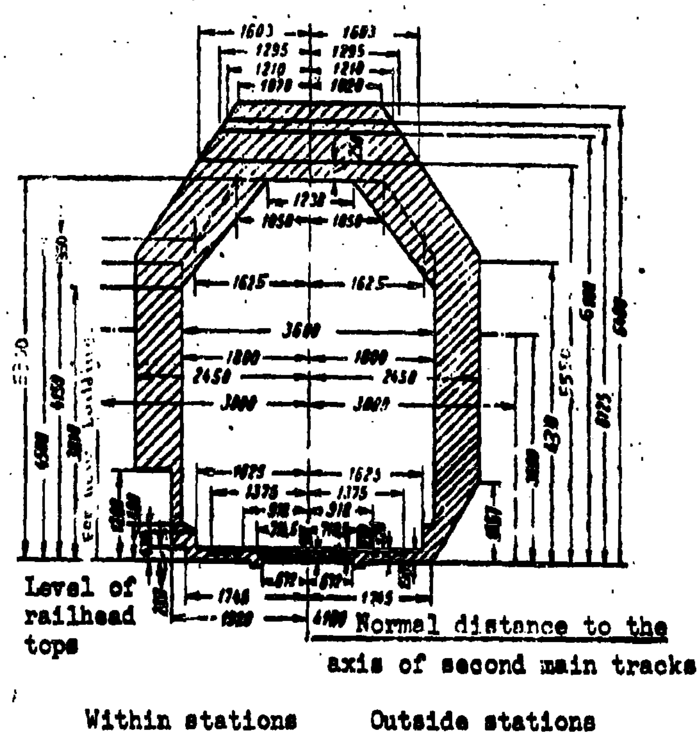



Fig. 8. OCT BKC 6435, perimeter 2-C

[This figure is taken from source [2], p. 65, with dimensions corrected according to the Tekhnicheskiy zheleznodorozhnyy slovar', 2nd edition, Moscow, Zheldorizdat, 1946 (compiled by B.N. Vedenisov et al.).]

in countries with 1435-mm track. Rolling stock with the 0-T perimeter (Fig. 4) can operate only on certain reconstructed sections of 1435-mm main lines in countries which are members of OSZhD, the Organization for Railroad Cooperation, founded in 1956 and encompassing the 12 countries of the Communist bloc (Albania, Bulgaria, Hungary, East Germany, Vietnam, Red China, North Korea, Mongolia, Poland, Rumania, the USSR, and Czechoslovakia) [3]. Rolling stock with the 01-T perimeter (Fig. 5) can operate on all 1435-mm main lines of the OSZhD countries. Rolling stock with the 02-T perimeter (Fig. 6) can operate on all 1435-mm lines of the OSZhD countries and also on the 1435-mm lines of the railroads which were members of the now abolished Union of Middle European Railroads. Finally, rolling stock with the 03-T perimeter (Fig. 7) can operate on all European and Asian railroads with 1435-mm track.

In the old ЭCT ВК6435, two track clearances were specified -- the 1-C, used prior to 1926, and the 2-C(Fig. 8), which became effective in 1926 [2]. This standard also specified separate clearances for tunnels -- CT-1 and CT-2. (The 1 and 2 apparently have the same meaning as they do in designations for track clearances.)

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

## TOPIC A-2. ROAD TRANSPORTATION

1.) Andreyev, F. G., I. A. Tsentsiper, and Ye. M. Bokova. Tank truck for the transport of liquefied gases. Gazovaya promyshlennost', no. 1, 1961, 32-35.

A tank for the transportation of liquefied gases, primarily of the hydrocarbon type, has been designed by the Institute of Giproniigaz. The tank has an ID of 1600 mm and is 7600 mm long. Total capacity is 14.6 $m^3$, and useful capacity, 12.4 $m^3$. It is made from 14-16-mm-thick Ст 3 steel plate [killed commercial-grade steel with 0.14-0.22% carbon].

The tank has separate filling and emptying lines. For emptying, the tank is equipped with a self-contained pump driven by an engine which uses gas from the tank. The tank is mounted on the 52155 frame of the МАЗ-200В truck.

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

## TOPIC B. CONSTRUCTION ACTIVITIES ASSOCIATED WITH MISSILE SITES

1.) Utkin, L. A. On the study of the seismic effect of powerful explosions. IN: Akademiya nauk SSSR. Ural'skiy filial. Gorno-geologicheskiy institut. Podzemnaya razrabotka rudnykh mestorozhdeniy (Underground mining). Sverdlovsk, 1960, 125-130. (ITS: Trudy, vyp. 54).

Powerful blasts with explosive charges up to 200 tons not only cause local destruction of rock but also considerable elastic deformation of the surrounding massif. Such elastic deformation converts into a certain amount of elastic energy which propagates as seismic oscillations into the surrounding area. The subsequent vibration of the massif is determined by its elastic properties and continues for some time after detonation is completed. This phenomenon is called the seismic effect.

In spite of the importance of the seismic effect, only during the past few years has any study of it been undertaken. The size of the zone affected by seismic effect depends on the amount of explosive charge, the properties of the medium in which the seismic waves are propagating, the distance from the explosion site to the point of observation, and the strength of the object subjected to the action of the explosion.

The amplitude of the massif displacement can serve as a criterion for seismic-effect evaluation. Some authors (M. A. Sadovskiy, F. A. Kirillov, and D. D. Barkan), however, use the velocity of rock vibration as a criterion in evaluating seismic effect. Two methods can be used in determining the influence of the seismic effect on the stability of rock and underground areas. Stresses can be determined from the velocity of rock vibration or by direct measurement of the pressure caused by powerful explosions in the objects under study.

Five methods for the study of the seismic effect of powerful explosions are considered:

1) Visual observations. The data of visual observations can play an important role in the study of the stability of rock and underground areas subjected to the seismic effect. According to this method, brittle materials are placed in the action zone of the explosion (e. g., concrete plate, as was suggested by S. I. Popov, Docent, Magnitogorsk Institute of Mining and Metallurgy). A recess 800 x 800 x 40 mm is filled with concrete or other material and after each, or several, explosions the number and the position of cracks occurring are recorded as they relate to the amount of explosive charge, the distance from the explosion, etc. The results are compiled and are used as preliminary

data for the study of seismic effect.

2) The МИКС method. This method, developed by the Institute of the Physics of the Earth, is based on the measuring of seismic vibrations caused by powerful explosions by means of multichannel recording of vibrations of structures and the ground . According to this method, the vibrations from seismic detectors at different locations are simultaneously recorded by a 6- or 12-channel oscillograph.

The ПО-12 and ПО-14 magnetoelectric oscillographs (12 and 14 channels, respectively) serve for recording vibration of the ground caused by explosions. The oscillographs are supplied with 24-v d-c power from a 50 ampere-hours lead-acid battery. According to data of the Institute of the Physics of the Earth, the recording speed of 150-250 mm/sec is the optimal speed for the oscillograph band.

Electrodynamic seismic detectors (vibrographs) are used for recording displacements of the massif. Seismographs of the СПМ-16 type are used primarily for recording vibrations of structures subjected to action from outside sources. The vibrographs are based on conversion of mechanical motion (vibration) into electromotive force. They can record both vertical and horizontal components of vibration.

3) Wire-gage method. The third method is based on strain-sensitive wire gages widely used in the machine industry. Since the modulus of elasticity of rock is lower than that of steel, it is considered that this method can be successfully used for the study of the state of stress in rock, particularly in dynamic processes occurring rapidly. The method is especially advantageous in that it permits the direct measurement of stresses caused by an explosion as well as the measurement of residual deformations.

4) Piezoelectric method. This method is based on the piezoelectric effect. Crystals of Rochelle salt, tourmaline, quartz, ammonium phosphate, barium titanate, and others can be used. For this method the author recommends the establishment of technical specifications and the development of piezoelectric pickups, mainly from barium titanate, according to these specifications.

5) Ultrasonic method. This method can be used for the study of rock disturbances by measuring the velocity of ultrasound propagation. Modern ultrasonic instruments make it possible to test rock at a depth of 2-3 m and more.

For the processing of experimental data in the determination of seismic effect, the following equations are given for the sinusoidal vibration:

$$v = \frac{g\,T}{2\pi} \quad \text{(cm/sec)}, \qquad (1)$$

where v = maximum amplitude of the velocity of vibration; g = maximum amplitude of acceleration, cm/sec; and T = period of vibration, sec.

$$g = \frac{a}{u} \quad (cm/sec^2), \qquad (2)$$

where a = amplitude of acceleration, cm/sec, and u = magnification of the instrument for the given period.

$$A = \frac{vT}{2\pi} \quad (cm), \qquad (3)$$

where A = maximum amplitude of the displacemen..

$$\varepsilon_{max} = \frac{v}{s}, \qquad (4)$$

where s = velocity of the seismic wave, cm/sec.

$$\sigma_{max} = E \cdot \varepsilon_{max} \ (kg/cm^2), \qquad (5)$$

where E = modulus of rock elasticity determined under laboratory conditions, kg/cm².

$$r = \sqrt[3]{\frac{k_v^2 \, Q}{v_0^2 \, \gamma s \, T} g_1} \quad (m) \qquad (6)$$

where r = radius of the seismic danger zone; $k_v$ = seismic characteristic of the explosion, $(7.5 \cdot 5 \cdot 10^4)$, cm; Q = weight of the explosive charge, kg; $v_0$ = velocity of seismic oscillations, cm/sec; $\gamma$ = unit weight of the rock, kg/m; and g = acceleration of gravity, 9.81 m/sec.

The data obtained on the seismic action of explosions can be used in design calculations for determining rational dimensions of chambers and pillars, maximum weight of explosive charges, and the safe radius of explosion action.

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

## TOPIC B-1. EXCAVATING AND GRADING ACTIVITY

1.) Epshteyn, Ye. F., E. I. Arsh, and G. K. Vitort. Novyye metody razrusheniya gornykh porod (New methods of rock breaking). Moskva, Gostoptekhizdat, 1960, 85 p.

Methods of rock drilling experimented with in the Soviet mining industry include the electrohydraulic method, thermal methods, and a number of electrophysical methods.

### Electrohydraulic Method

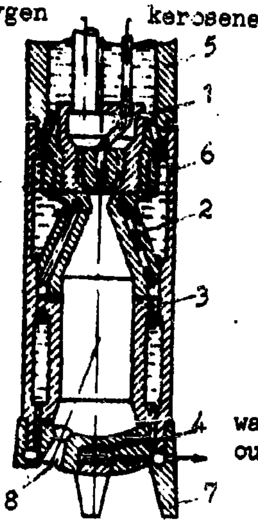
With this method rock is fractured by a pressure wave created by a high-voltage discharge in a water-filled blasthole. In 1957-1959 a series of production-scale experiments was conducted to determine the feasibility and efficiency of electrohydraulic drilling. The results indicated that the method is practical only for fragmentation of large pieces of rock into smaller ones. For rock cutting and drilling, the electrohydraulic method was found to be noncompetitive with conventional methods. [pp. 32-45]

### Thermal Methods

Soviet study of thermal methods of rock drilling and the development of flame-jet cutters began in 1950. Research is presently being conducted at the Moscow Mining Institute, the Kazakh Mining and Metallurgical Institute, the Moscow Higher Technical School imeni Bauman, Giprorudmash, and other organizations.

In the development of the burners Soviet specialists concentrated mainly on the rotary multinozzle type. (See illustration.) In 1958 Giprorudmash built the first experimental unit and field tested it the following year. At the most effective rotation rate, drilling rates up to 9.6-10 m/hr were achieved in secondary quartzites with Protod'yakonov strength factor f = 10-12. The presence of water does not lower the drilling rate but the inclusion of soft or caolinized rock lowers it appreciably (30-50%). Similar results were obtained

with manual, single-nozzle burners.




Flame-jet burner

1 - fuel atomizer; 2- body
3 - combustion chamber;
4 - face; 5 - connecting piece; 6 - housing; 7 - support; 8 - nozzle.

The following is a general summary of the results of laboratory studies and field tests on thermal drilling methods:

1) The character of the process of rock destruction by flame jet is determined not by the temperature but by the temperature gradient, which in turn depends on the mineral composition of the rock, the nature of ore inclusions, the body structure of the rock, and the parameters of the flame jet. Structural transformations such as occur in quartz increase the effect of the temperature gradient.

2) In some types of oxidized and nonoxidized ores found in large monolithic formations, boreholes are produced by destruction of the rock without melting. In this case, the maximum drilling rate is achieved.

3) Inclusions of chlorite--biotite shale and nonuniform ore inclusions contribute to full or partial melting of the rock and lower efficiency of flame-jet drilling.

4) In a distrubed rock formation, the borehole formation is accompanied by partial melting of the rock and 50-60% reduction of the drilling rate compared to that obtained in monolithic rock. The nature of the rock-destruction process can be changed with the use of multiple-nozzle burners with variable rates of nozzle rotation. [ pp. 49-54]

## Electrophysical Methods

Research work on destruction and weakening of rock by heating with high-frequency current has been conducted since 1949 at the All-Union Scientific Research Institute for Coal (VUGI) and at the Mining Institute, Academy of Sciences USSR. Destruction of rock by induction heating and by means of electrical-pulse discharge has been studied at the Dnepropetrovsk Mining Institute as well as at VUGI.

A mining machine designed at VUGI has a combination device which breaks or weakens the rock by means of a high-frequency electric field and provides mechanical removal of rock and finishing of the shaft walls. The productivity of the machine in cutting a shaft with an 8-10-$m^2$ cross section is 1.5-2.0 m/hr through hard rock.

Rock destruction by means of a high-frequency magnetic field was found to be less efficient than the method just presented. Experiments were also conducted on rock destruction by direct application of electric current. Findings indicate that although high-voltage electrical-pulse discharge can be used for secondary fracturing of porous rock, it is ineffective against strong rock. A high-frequency electrical-contact method is more promising and simpler.

With the electrical-contact method, a high-frequency electric current is passed through rock, heating the rock under the electrodes and producing a current-conducting channel between them. Rapid, intense heating of the rock follows formation of the channel and sets up thermoelastic stresses sufficient for rock breaking. The method can be used for breaking any strong rock.

In the summer of 1959 field tests were conducted on the first experimental mobile unit employing the contact method. The unit was built at the Dnepropetrovsk Mining Institute. Iron ore blocks weighing from 200 to 14,000 kg were broken in 30-180 sec. The power consumption was 1-3 kw-hr/ton, initial voltage was 1000 v, current was 50 amp, and frequency was 50-70 kc.

According to Soviet scientists, the electrical-contact method of rock breaking is suitable for secondary rock fragmentation. The application to primary rock breaking in large underground excavations requires further theoretical and experimental research. [pp. 60-79]

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

TOPIC B-4. CONSTRUCTION EQUIPMENT

1.) Filina, T. A. Instruments for quality control of concrete and reinforced-concrete structures. Beton i zhelezobeton, no. 3, Mar 1961, 111-118. TA680. B38 1961.

In the 1960 Exposition of the Achievements of the National Economy, the "Construction" section put on display 80 instruments for investigation and control of quality of concrete and reinforced concrete. These instruments were developed and manufactured by 30 different organizations. According to principle of operation, they were classed as pulse, tuned, impact, radiometric, and mechanical.

Among the instruments exhibited, there were six different types of ultrasonic testers, all based on the lot-produced ИКЛ-5 . They are considered better than other Soviet and non-Soviet models. Lot production for one of the six, the ИКЛ-5-В , was suggested. This is an ultrasonic tester for measuring the time of passage of an ultrasonic pulse through concrete, rock, structural materials, ice, or frozen ground to determine quality and strength. The thickness of concrete which can be tested ranges from 2 cm to 15 m. The error in time measurement can vary within 0. 2 to 2 microsec.

Designed for automatic inspection of road and airport pavement and other constructions made of concrete or other materials, the МК-1 (ПИК-6) device measures and records differences in impact-wave signals in the structure being tested. The number of shocks against the structure is varied from 1 to 100 sec.

A radioactive densimeter for measuring unit weight of freshly compacted concrete within 2 to 4. 5 $t/m^3$ is used in the construction of hydroelectric and nuclear power plants. In the latter, it measures the density of concrete to be used for biological protection. This device is based on the principle of the absorption of radioactive emission by concrete. Measurement accuracy is 1. 5-2%; the time required for one measurement is 30-40 sec. Another device for the same purpose is a radioactive probe, which can measure the density of rock and concrete as well as filtration flow in the mass of earth and concrete structures.

Several instruments for measuring parameters of reinforcing bars should also be noted. The ПН device measures stresses in prestressed reinforcing bars and is particularly important in electrothermal stretching of reinforcing bars. The КРК-1 vibration-frequency meter measures frequencies (and hence stresses) in reinforcing bars. The ЦНИИЛ Д-1, ДК-3, ДС-50, and ЭД-1 all measure stresses in reinforcing bars.

The ВП-1 electronic hygrometer is used for measuring moisture content in sand used in the preparation of concrete mixtures. The ДМ-2 device measures specific surface area of cements and other powder materials and is based on the principle of determining air permeability at low air pressure (less than 1 mm Hg). Another device measures air content in concrete mixes and can be used under laboratory conditions and in industrial inspection.

Other instruments at the Exposition included a vibratory viscosity meter based on the immersion of a hollow ball in a mixture subjected to vibration, a universal testing installation for bending and torsion tests of concrete under laboratory and industrial conditions, and an electrodynamic deflection meter for measuring deflections of structural elements under static or dynamic loads.

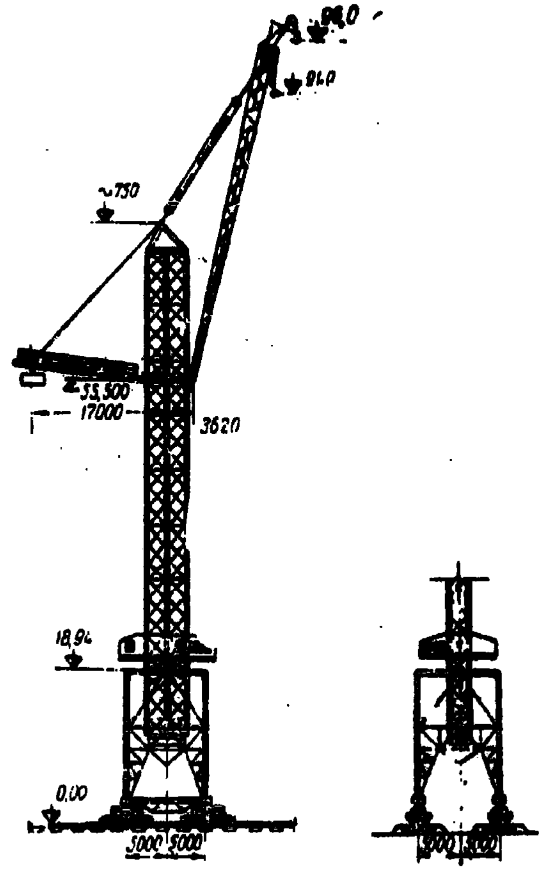
2.) Gitman, I. B., and L. N. Shchipakin. The БК-1425 erection tower crane, 75-ton lifting capacity. Novaya tekhnika montazhnykh i spetsial'nykh rabot v stroitel'stve, no. 9, Sep 1959, 5-10.

In 1958 the Promstal'konstruktsiya Design Institute completed the design of the first erection tower crane, the БК-1425 (see illustration), with a 75-ton lifting capacity. The crane was built at the Ramenskoye and Orsk plants of the Ministry of Construction RSFSR and tested in March 1959. It was effectively used on the construction of a blast furnace of the Nizhniy Tagil Metallurgical Combine.

The БК-1425 has the following characteristics:

Lifting speed of main hook for 75 t: 0.8, 3.6, 6.4 m/min.
Lifting speed of main hook for 30 t: 2.0, 9.0, 16.0 m/min.
Lifting speed of auxiliary hook for 5 t: 9.0, 32.0, 55.0 m/min.
Lifting capacity, 75-t maximum for 19-m boom.
Lifting capacity, 20-t maximum for 50-m boom.
Speed of rotation, 0.19 rpm.
Moving speed, 12.2 m/min.
Total capacity of motors, 200 kw.
Total weight, 393 t (54-t counterbalance).
Lift, 98-m maximum.

The crane moves on four double-rail bogies with eight wheels each under power of four 5-kw motors. In the cabin of the crane operator, a two-way radio is installed.




БК-1425 crane

3.) Karasev, N. F., V. G. Matsyuk, V. I. Razmerov, P. A. Chasovitin, and N. Ye. Cherkasov. Novaya tekhnika v stroitel'stve tonneley metropolitenov SSSR (New technique in the building of Soviet subway tunnels). Moskva, Transzheldorizdat, 1959. 139 p.

The three tunneling machines used in building the Leningrad, Moscow, and Kiyev subway tunnels are adaptations of the conventional shield and are similar in design and function. They differ only in the design of the cutter heads, reflecting the differences in rock properties in the three localities. The Moscow rock was medium-strength, the Leningrad rock was soft, and that of Kiyev was a moist clay.

## The Moscow Machine

The machine used in Moscow (Fig. 1) was built for tunneling in solid rock with compression strength up to 400 kg/cm$^2$. It consists of shield *8* with propelling hydraulic jacks, fixed bottom plate *6* with hydraulic feeding jack *3*,

upper plate *7* carrying two cutter heads *1*, motors and reducing gear trains *2* for the cutter heads, bucket ring *4*, and scraper conveyor *5*.

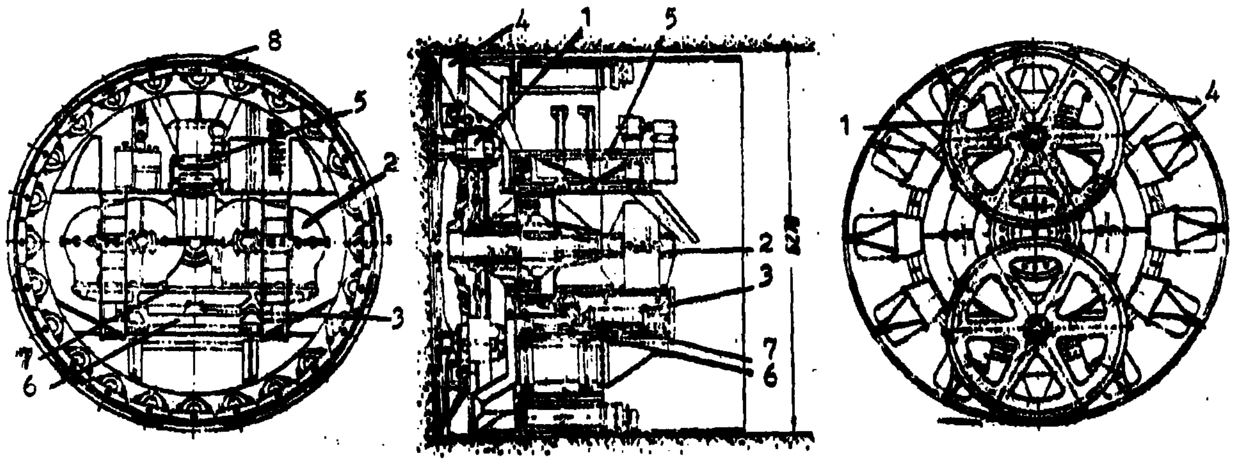



Fig. 1. Mechanized shield for tunneling in medium-strength rock

The cutter heads *1* (Fig. 2), each equipped with 12 drag-type bits, are driven by two 55-kw motors *4* (Fig. 2) through reducing gear trains *3* and *2*, carrier *5* and planetary gear system with stationary sun gear *6* and satellite gears *7*, each mounted on the same shaft as its cutter head. In operation the carrier rolls the satellite gears around the sun gear, and both cutter heads rotate around their axis and simultaneously around the axis of the sun gear, with each bit cutting an epicycloid-shaped groove in the rock (Fig. 3). Rock particles fall into the buckets and from the buckets into the scraper conveyor, which carries them to trucks in the rear of the machine.

The feeding jack pushes the upper plate and the cutter heads forward at a rate of up to 10-12 mm/min. The length of the working stroke is 570 mm. At the end of the working stroke, the upper plate with the cutter heads is pulled back into the initial position, the whole shield is pushed forward until the cutter heads come into contact with the rock front, and the whole cycle is repeated.

After some design corrections and the elimination of certain initial difficulties, the Moscow machine was making tunnel 6.27 m in diameter at a rate of 200 m per month (25 working days, 3 shifts per day). The average compression strength of the rock was 128 kg/cm$^2$. Power consumption varied from 108 to 196 kw-hr/m of tunnel length, depending on rock strength, bit sharpness ( ВК-8 carbide), and feed rate. Hard alloy consumption was

105.6 g/m of tunnel length.

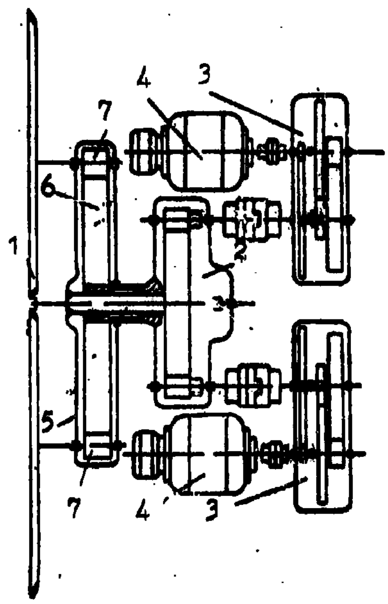



Fig. 2. Kinematic diagram of the mechanized shield.

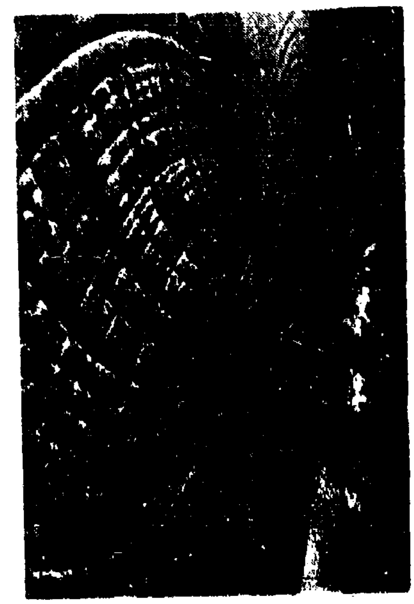


Fig. 3. Tunnel face.

## The Leningrad Machine

The machine used in Leningrad was built for rock with compression strength of 40-80 kg/mm². It has six cutter heads -- four outside heads with 18 bits each and two inside heads with 13 bits each (Fig. 4). The cutter heads are driven by a single 100-kw motor through reducing trains, carrier, and planetary gear system made up of a rotating sun gear which meshes directly with the satellite gears of the two inside cutter heads and through idler gears with the satellite gears of the four outside cutter heads (Fig. 5).

In operation all the cutter heads are rotated around their own axes by the sun gear and rolled around the sun gear by the carrier. Otherwise, the Leningrad machine operates in the same manner as the Moscow machine. The length of the working stroke of the feeding jack is 575 mm, the rate of feed is 13-16 mm/min, and the tunnel diameter can be 5.63-5.66 m. One working cycle is 43-50 min. Output per shift is 3-4 m; output per month is up to 228 m. Power consumption is 3-4 kw-hr/m³.

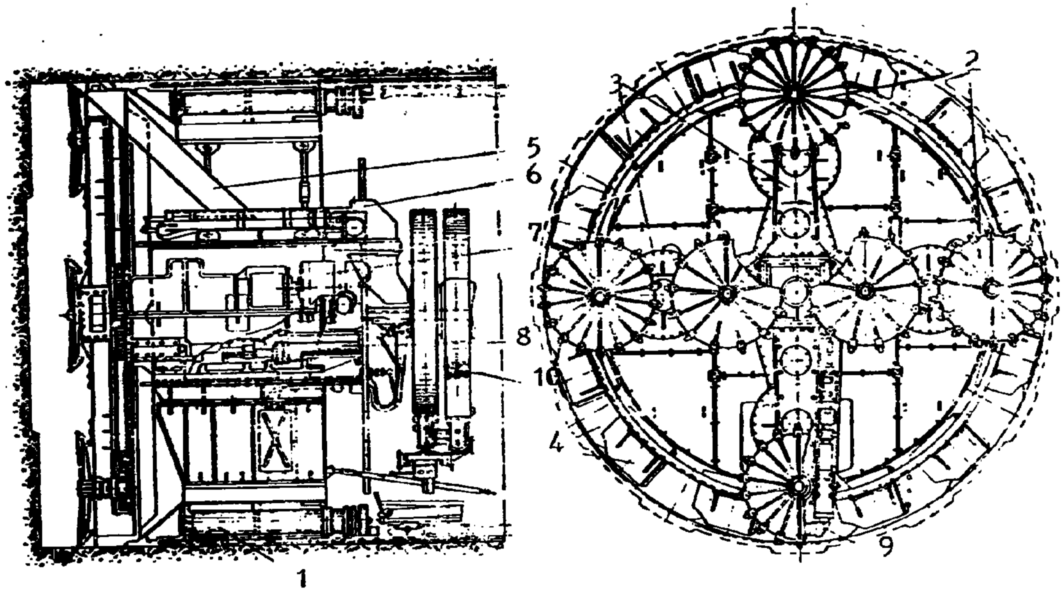



**Fig. 4. Mechanized shield for tunneling in soft rock.**

1 - shield; 2 - cutter heads; 3 - carrier; 4 - bucket; 5 - trough; 6 - conveyor; 7 - reducing gear train; 8 - hydraulic feeding jack; 9 - cutoff bit; 10 - tube-laying device.

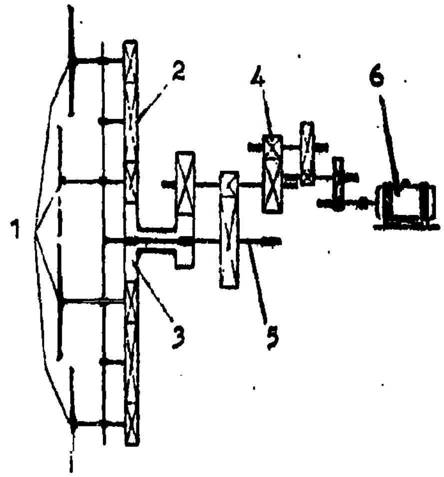



Fig. 5. Schematic diagram of the Leningrad tunneling machine

1 - cutter head; 2 - idler gear; 3 - sun gear; 4 - reducing gear train; 5 - main shaft; 6 - motor.

## The Kiyev Machine

The machine used in the Kiyev tunnel has only one cutter head (Fig. 6) with four radially arranged drag-type cutters projecting 15-20 mm through windows 4, 5, 6, 7. Located on the periphery of the cutter head is a cutoff bit, which maintains the correct shape and size of the tunnel. Another bit located on the periphery is used to increase the tunnel diameter at curves.

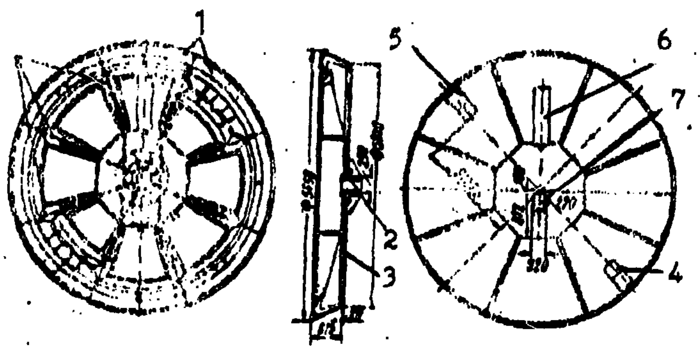



Fig. 6. Cutter head of the Kiyev tunneling machine

1 - disk sector; 2 - disk hub; 3 - steel plate; 4, 5, 6, 7 - windows for cutters.

This machine cut a 1400-m tunnel in clay with a compression strength of 10 kg/cm$^2$ at an average rate of 1.7 m per shift, 5 m per three-shift day, and 117 m per month. Actual cutting time was only 22-34% of the working cycle, and with some improvements and better organization could be increased to 67%. The power consumption varied from 20 to 130 kw-hr/m of tunnel length and depended mainly on the feed rate.

None of the three machines has any gripping devices to take up the torque reaction of the cutter heads; only the dead weight of the unit itself serves this purpose. This dead weight is not always sufficient, and torque reaction can sometimes turn the whole unit in the direction opposite to the rotation of the cutter heads. To bring the unit back to its correct position, the rotation of the cutter heads is reversed.

4.) Prussak, B. N. Standardization of rotary excavators. Standartizatsiya, no. 1, Jan 1961, 18-19. TS9.S8 1961.

In this article discussing the standardization of rotary excavators, standard specifications are given for several types of rotary excavators planned for lot production.

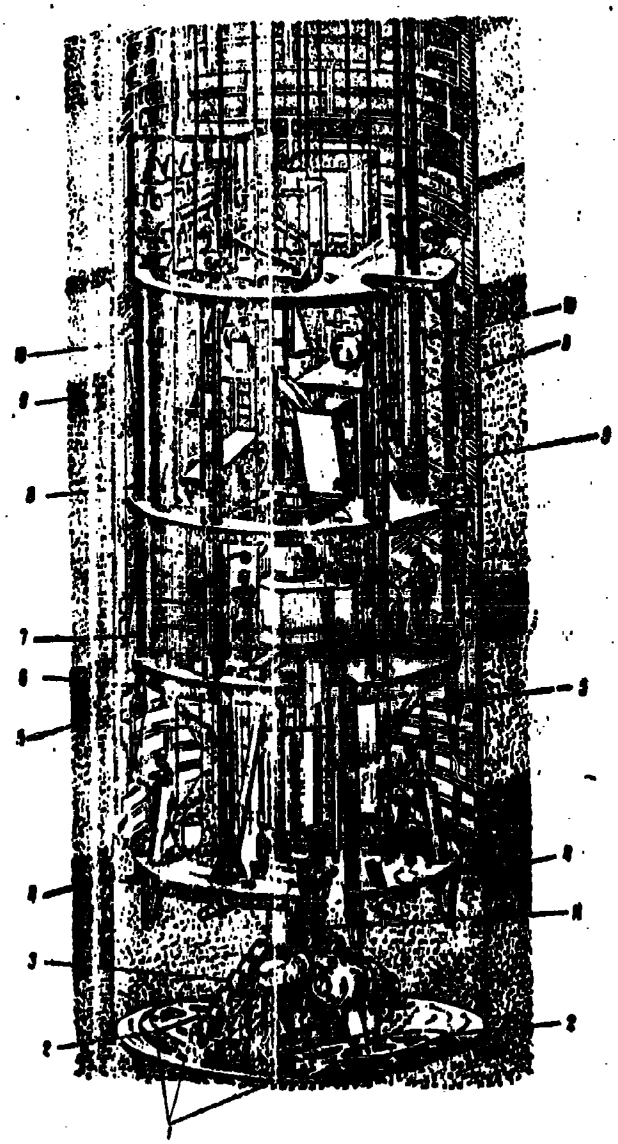
The following data are given on a self-propelled rotary excavator, the ЭРК 1600, designed for open-pit mine working:

Bucket capacity, 1600 liters.
Height of digging (above ground), 50 m.
Depth of digging (below ground), 20 m.
Total height of digging, 70 m.
Productivity (loose ground), 5000 m$^3$/hr max and 3500 m$^3$/hr min.
Specific cutting force, 120 kg/cm$^2$ max and 90 kg/cm$^2$ min.
Approximate weight, 3800 t.

5.) 1 Rapoport, P.I., and A.I. Gornopol'skiy. Sovremennyye mashiny dlya prokhodki vyrabotok ugol'nykh shakht (Modern machinery for sinking coal shafts). Moskva, Trudrezervizdat, 1958. 165 p.

2 . A machine that goes deep into the earth. Yunnyy tekhnik, no. 4, Apr 1961, 32 I.

The Central Scientific Research Institute of Underground Mine Construction has designed a shaft-sinking unit, the ПД-1М [2]. The ПД-1М can sink shafts up to 6.5 m in diameter and over 300 m deep in medium-strength rock with water flow up to 50 m$^3$/hr [1, p. 69]. The unit is 17,120 mm high, its weight is 160 tons, and its sinking rate is 0.4 m/hr.



The ПД-1М shaft-sinking unit

1 - cutting heads; 2 - disks; 3 - bucket conveyors; 4 - hydraulic jack; 5 - pneumatic hoists; 6 - monorail ring; 7 - hydraulic jacks; 8 - dump bins; 9 - wedge; 10 - hydraulic jack; 11 - vertical elevator

The ПД-1М (see illustration) consists of four platforms and is suspended on eight cables through parallel-connected hydrocylinders to insure equal tension on the cables. The rock-cutting mechanism consists of two disks 2 with cutting heads 1. Each disk revolves around its own axis while simultaneously revolving around the axis of the shaft. The crushed rock is carried by two bucket conveyors 3 into vertical elevator 11, which lifts it to dump bins 8. The reinforced-concrete lining is erected with two pneumatic hoists 5 which move along monorail ring 6.

In operation the unit is secured by lower hydraulic jack 4 and upper hydraulic jacks 7 and 10 and wedge 9. The ПД-1М is controlled by one operator and a 10-12 man crew. It can sink up to 180 m per month. [1]

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

TOPIC C-7. GUIDANCE OPERATIONS FACILITIES

1.) Khudinskiy, L. L. Heterodyne amplifier of seismic pulses. (Authors' Certificate No. 136900, 15 Aug 1960). Byulleten' izobreteniy, no. 6, Mar 1961, 49. T285.A32 1961.

The analyzer consists of a sharply tuned quartz filter, an electron amplifier, and a loop oscillograph. To improve accuracy and speed of operation a multivibrator and an electron tube for generating rectangular pulses are used.

The multivibrator is the delayed-response type and is triggered by the trailing edge of the pulse being analyzed. It generates rectangular pulses and blocks the amplifier tube for the period of forced vibration of the filter.

The rectangular pulses generated by the electron tube are of negative polarity and create pulse-controlled negative feedback in the filter circuit before the passage of the next pulse to be analyzed.

2.) Slutskovskiy, A. I., and G. V. Bereza. Device for testing amplifiers of seismic-survey stations. (Authors' Certificate No. 136899, 11 Jul 1960). Byulleten' izobreteniy, no. 6, Mar 1961, 49. T285.A32 1961.

There are two variations of the device. In the first, testing is conducted by feeding oscillations simulating explosions into the input of the amplifier. The operation makes use of a photoreproduction unit, a programming device, and a reproduction amplifier. In order to increase the range of simulated oscillations and to obtain proper sequence of pulses, a multicontact step switch is employed. The switch is made in the shape of a disk which carries contacts around its circumference. Resistors are connected to the contacts, and the cursor of the disk is joined to the axle of a drum of the photoreproduction unit.

The second variation is similar to the first but has a sound generator substituted for the photoreproduction unit and uses punched-tape program control. The tape is placed on the revolving drum carrying a pair of sliding contacts for switching the bypass resistor of the generator on and off.

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

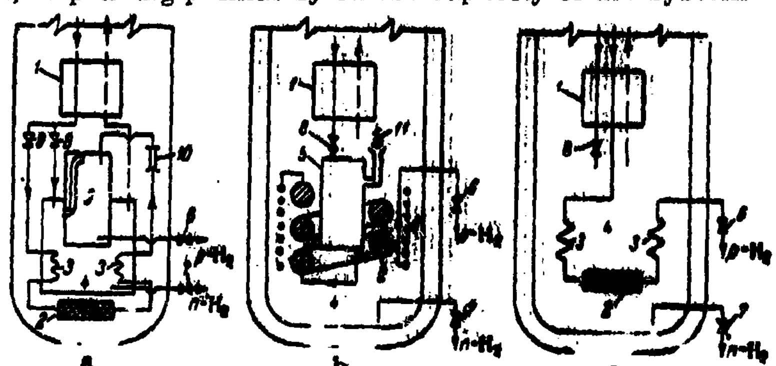
## TOPIC D-2. PROPELLANT-HANDLING EQUIPMENT

1.) Buyanov, R. A., A. G. Zel'dovich, and Yu. K. Pilipenko. Some problems in the technology of producing liquid parahydrogen. Khimicheskaya promyshlennost', no. 2, Feb 1961, 31-34. TP 1. Z6 1961.

Fresh liquid hydrogen usually consists of approximately 75% orthohydrogen and 25% parahydrogen, a composition which corresponds to the equilibrium state for temperatures above 300° K. Such a composition, however, slowly changes: orthohydrogen is transformed into parahydrogen. The transformation reaction is exothermic, and the amount of heat it produces, 253 cal/mol, exceeds the heat of vaporization of liquid hydrogen, which is 228 cal/mol, at normal pressure. The resultant evaporation is responsible for significant losses of liquid hydrogen during storage -- 18% in the first 24 hours, 40% in the first four days.

Storage losses can be avoided by converting all of a given volume of liquid hydrogen into the para-modification, which can be stored for months without heavy losses. At a parahydrogen content of 95-98% losses after two months amount to only 10%.

Conversion is usually brought about during the liquefaction process in a reactor directly connected into the liquefaction system. The temperature in the reactor is 21-24° K. To accelerate the conversion reaction chromium-nickel and $Fe(OH)_3$, $Cr(OH)_3$, and $Mn(OH)_4$ hydroxide catalysts are used. Several methods of connecting the conversion reactor into a liquefaction system are used, depending primarily on the capacity of the system.



1 - heat exchanger; 2 - reactor; 3 - cooling coils; 4 - collector for ordinary hydrogen; 5 - intermediate collector; 6 - parahydrogen valve; 7 - valve for ordinary hydrogen; 8, 9 - throttling valves; 10 - throttling capillary; 11 - helium valve. $nH_2$ - ordinary hydrogen; $pH_2$- parahydrogen.

Method *a* (see illustration) is recommended primarily for adaptation to existing liquefying plants. After leaving heat exchanger 1, the flow of high-pressure hydrogen is divided into two streams. One stream passes through the conventional liquefying cycle, beginning with throttling valve *8*; the ordinary liquid hydrogen is collected in collector *4* and removed through valve *7*. The other stream passes through throttling valve *9*, is completely liquefied in the first cooling coil *3* (cooled with the ordinary hydrogen), and enters conversion reactor *2*, where the orthohydrogen is converted into parahydrogen. The heat evolving from the conversion reaction raises the temperature of liquid parahydrogen by 3-4° K, causing part of it to vaporize. The parahydrogen is, therefore, passed through a second cooling coil *3* and from there through throttling capillary *10* into collector *5*, from which it is filled into Dewar containers for storage.

One disadvantage of this method is the overheating of the hydrogen in the conversion reactor, which lowers the parahydrogen concentration to 92-93%.

Method *b* is suitable for medium-size liquefaction systems with capacities of 100-300 l/hr and for systems working with a refrigeration cycle. Here, all of the hydrogen from heat exchanger *1* goes through throttling valve *8* into collector *5*, in which helium valve *11* maintains a pressure of 1.8-3.0 atm. Part of the liquefied hydrogen passes through valve *11* into collector *4*, where the pressure is below 0.5 atm. Vapors follow the same route and are directed into the counterflow of heat exchanger *1*. Another part of the liquefied hydrogen from collector *5* goes into conversion reactor *2*, which is completely submerged in liquid hydrogen of ordinary composition. This provides for an extensive cooling and absorption of reaction heat and increases the concentration of parahydrogen in the final product to 99.7%.

In method *c* the parahydrogen cycle has a separate supply line; the hydrogen of ordinary composition serves only as a coolant and circulates in a closed circuit. The conversion system includes two cooling coils *3* -- one in front of and one behind the reactor -- and reactor *2*.

Method *c* is especially effective if the hydrogen for conversion is fed through absorbers (purifiers) containing activated charcoal which are cooled with liquid nitrogen. Since activated charcoal is also a catalyst, partial conversion occurs in the absorbers. By connecting an additional reactor cooled with liquid nitrogen into the system the parahydrogen content can be raised to 25-49% prior to the entrance of the conversion hydrogen into the main reactor. Method *c* is especially suitable for large liquefiers in which heat exchangers are built as separate units.

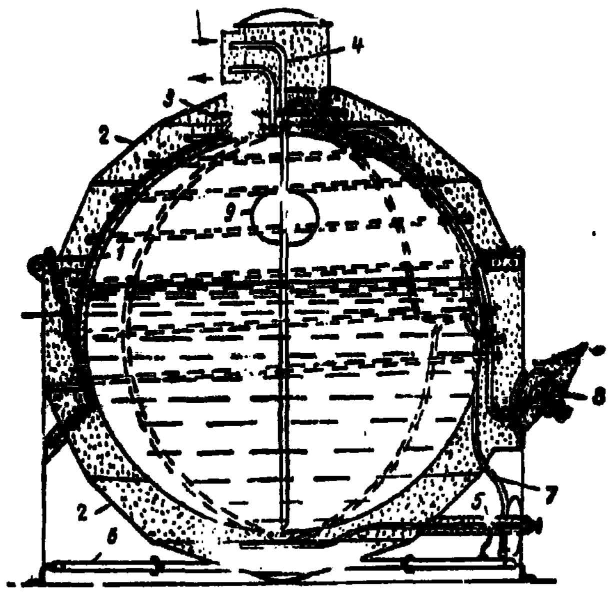
With all three methods maintenance of the lowest possible temperature in the conversion reactor is one of the essential conditions for successful operation. Productivity of a reactor is determined by the refrigerating capacity of the liquefying system and varies from 30 to 120 g/hr per $cm^2$ of the reactor cross section.

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

TOPIC E-4. LIQUID OXYGEN PLANT

1.) Romanyuk, A. A. Apparatchik kislorodnoy ustanovki (Oxygen-plant operator). Sverdlovsk, Metallurgizdat, 1959. 150-152.




Tank for storing liquid oxygen
1 - container; 2 - housing; 3, 4 - pipes; 5 - valve; 6 - gasifier; 7 - pipe for lowering pressure in tank; 8 - discharge valve for oxygen; 9 - hatch.

These stationary tanks for the storage of liquid oxygen are double-wall containers and consist of spherical thin-wall copper container 1 and housing 2, surrounding and supporting container 1. The space between 1 and 2 is filled with an insulating material such as magnesia powder. Pipe 3 continuously feeds some of the oxygen being evaporated into the interwall space to prevent absorption of moisture by the insulating material.

The container is filled with liquid oxygen through pipe 4. Valve 8 serves for emptying the tank but can also be used for filling it instead of pipe 4. During emptying, a certain amount of liquid oxygen is led through valve 5 to gasifier 6 and from there through pipe 7 back to container 1. The pressure of this gaseous oxygen forces the liquid oxygen out of 1 through valve 8.

Tanks of similar design mounted on trucks serve for the transport of liquid oxygen. The capacity of such a tank truck is 1300 kg and corresponds to about 1 $m^3$ of useful volume of the tank. About 30-40 min are required to empty the tank at a pressure in the tank of 0.5-0.6 atm.

SUBJECT: Quarterly Report - AID Work Assignment No. 13

PERIOD : 31 May 1961 to 15 Oct 1961

## BIBLIOGRAPHY


1. Andreyev, F. G., I. A. Tsentsiper, and Ye. M. Bokova. Tank truck for the transport of liquefied gases. Gazovaya promyshlennost', no. 1, 1961, 32-35.

2. Bakayeva, V. G., ed. Transport SSSR (USSR Transport). Moskva, Morskoy transport, 1960. 537 p.

3. Buyanov, R. A., A. G. Zel'dovich, and Yu. K. Pilipenko. Some problems in the technology of producing liquid parahydrogen. Khimicheskaya promyshlennost', no. 2, Feb 1961, 31-34. TP 1. Z6 1961

4. Epshteyn, Ye. F., E. I. Arsh, and G. K. Vitort. Novyye metody razrusheniya gornykh porod. (New methods of rock breaking). Moskva, Gostoptekhizdat, 1960. 86 p.

5. Filina, T. A. Instruments for quality control of concrete and reinforced-concrete structures. Beton i zhelezobeton, no. 3, Mar 1961, 111-118. TA680. B38 1961

6. Giant railroad cars. Ekonomicheskaya gazeta, 19 Jul 1961, 1.

7. Gitman, I. B., and L. N. Shchipakin. BK-1425 erection tower crane, 75-ton capacity. Novaya tekhnika montazhnykh i spetsial'nykh rabot v stroitel'stve, no. 9, Sep 1959, 5-10.

8. Karasev, N. F., V. G. Matsyuk, V. I. Razmerov, P. A. Chasovitin, and N. Ye. Cherkasov. Novaya tekhnika v stroitel'stve tonneley metropolitenov SSSR (New technique in the building of Soviet subway tunnels). Moskva, Transzheldorizdat, 1959. 139 p.

9. Khudinskiy, L. L. Heterodyne analyzer of seismic pulses. (Authors' Certificate No. 136900, 15 Aug 1960). Byulleten' izobreteniy, no. 6, Mar 1961, 49. T285. A32 1961

10. Machine that goes deep into the earth. Yunnyy tekhnik, no. 4, Apr 1961, 32 I.

11. Ostrov, A. B. New State Standards for railroad clearances. Zheleznodorozhnyy transport, no. 3, Mar 1960, 10-15.

12. Ostrov, A. B. Unification of railroad clearances of Socialist countries. Zheleznodorozhnyy transport, no. 2, Feb 1959, 87-93.

13. Prussak, B. N. Standardization of rotary excavators. Standartizatsiya, no. 1, Jan 1961, 18-19. TS9. S8 1961

14. Rapoport, P. I., and A. I. Gornopol'skiy. Sovremennyye mashiny dlya prokhodki vyrabotok ugol'nykh shakht (Modern machinery for sinking coal shafts). Moskva, Trudrezervizdat, 1958. 165 p.

15. Romanyuk, A. A. Apparatchik kislorodnoy ustanovki (Oxygen-plant operator). Sverdlovsk, Metallurgizdat, 1959. 150-152.

16. Slutskovskiy, A. I., and B. V. Bereza. Device for testing amplifiers of seismic-survey stations. (Authors' Certificate No. 136899, 11 Jul 1960). Byulleten' izobreteniy, no. 6, Mar 1961, 49. T285. A32 1961

17. Utkin, L. A. On the study of the seismic effect of powerful explosions. IN: Akademiya nauk SSSR. Ural'skiy filial. Gorno-geologicheskiy institut. Podzemnaya razrabotka rudnykh mestorozhdeniy (Underground mining). Sverdlovsk, 1960. 125-130. (ITS: Trudy, vyp. 54).